Predicting Monthly to Seasonal Climate Variability; the Oceanic and Atmospheric Causes and Effects

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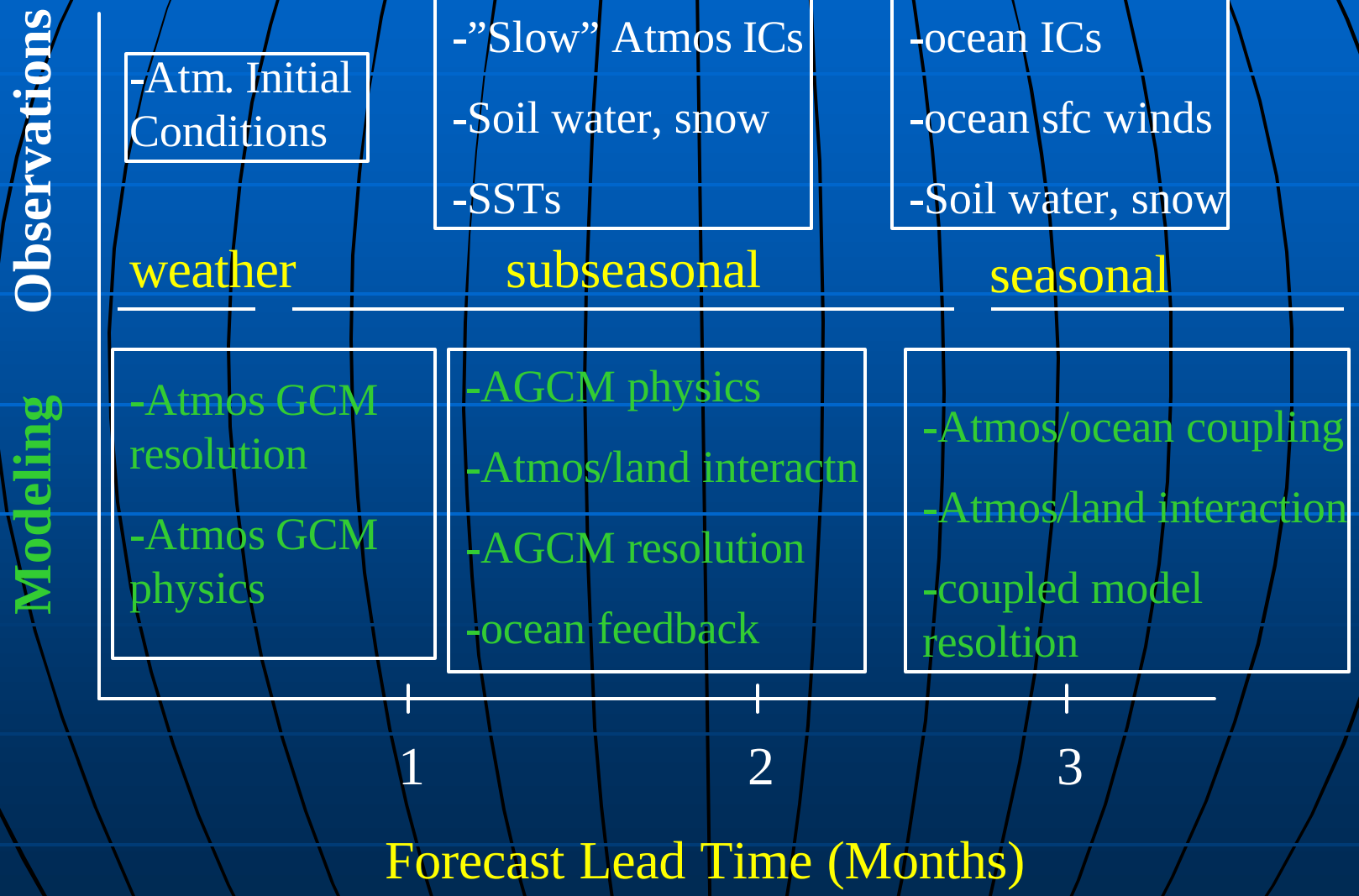
Outline

- Introduction
  - Weather, sub-seasonal, and seasonal prediction issues
- The seasonal prediction problem
  - The dominant role ENSO
  - A Stochastic Problem
- The sub-seasonal prediction problem
  - No single overriding phenomena
  - A bridge between weather and seasonal prediction
- NASA's role
  - Observations, modeling and data assimilation
  - Long term vision: evolve PDF from weather to seasonal and longer time scales

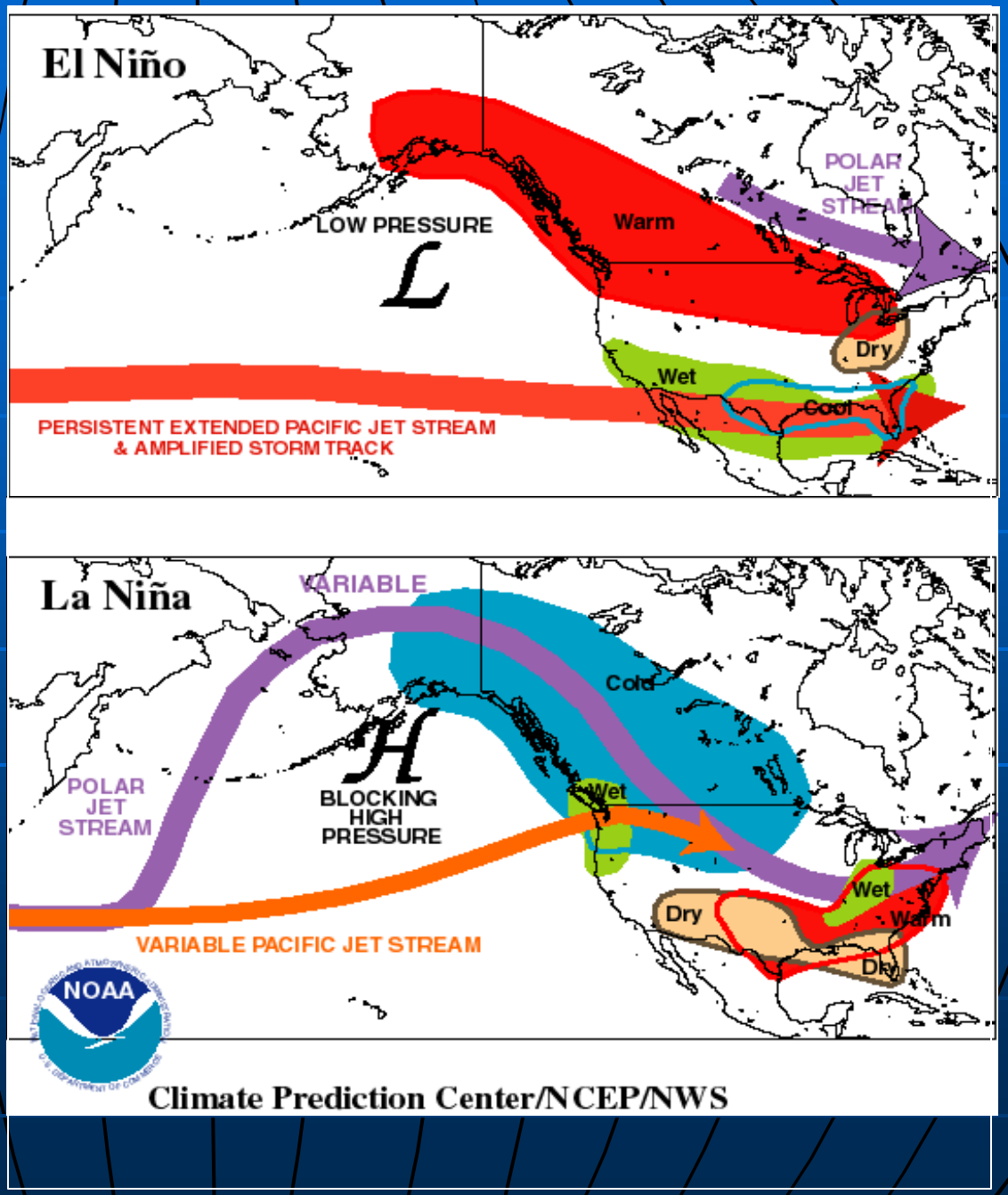
Observational and Modeling Priorities for Improved Forecasts



Dominant Role of ENSO in the Seasonal Forecast Problem

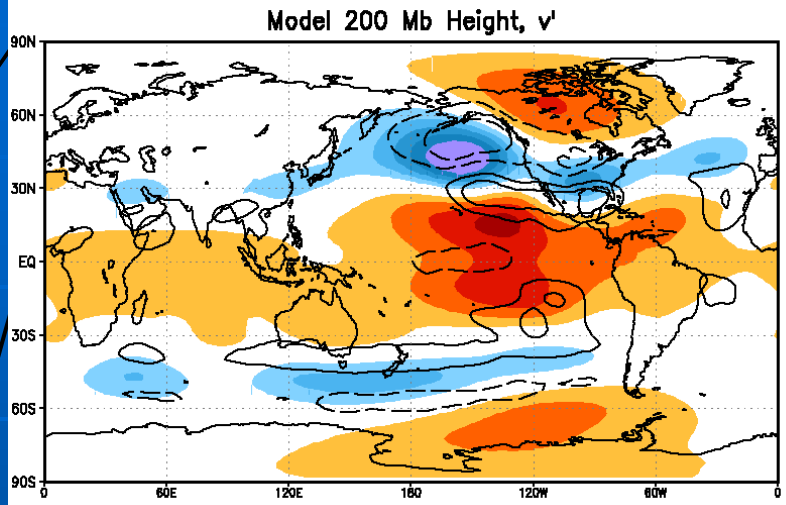
- Coupled models must be improved to better simulate ENSO variability
- Need improved ocean observations and data assimilation techniques to initialize coupled models
- Spring/summer season ENSO impacts require improved land/atmos coupling, soil moisture, snow observations
- Need to resolve ENSO impacts on weather
- Need to assess impacts of other ocean basins:
  - (Indian Ocean, Atlantic Ocean, non-ENSO Pacific warm pool)

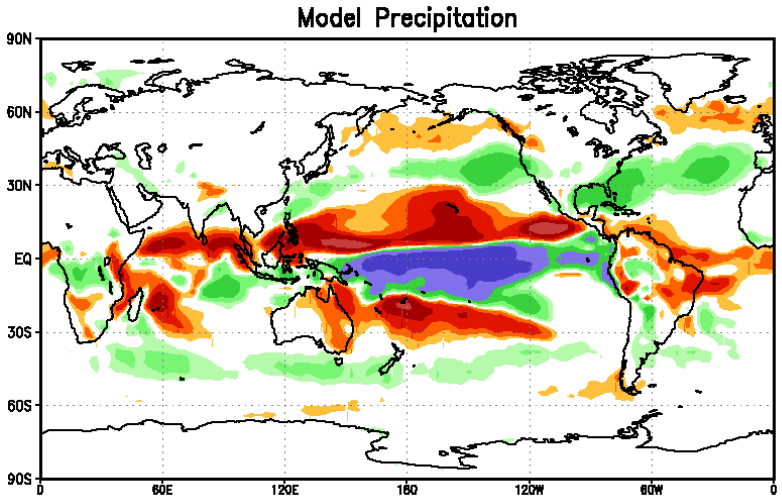
Typical January-March weather anomalies and atmospheric circulation during moderate to strong El Niño and La Niña

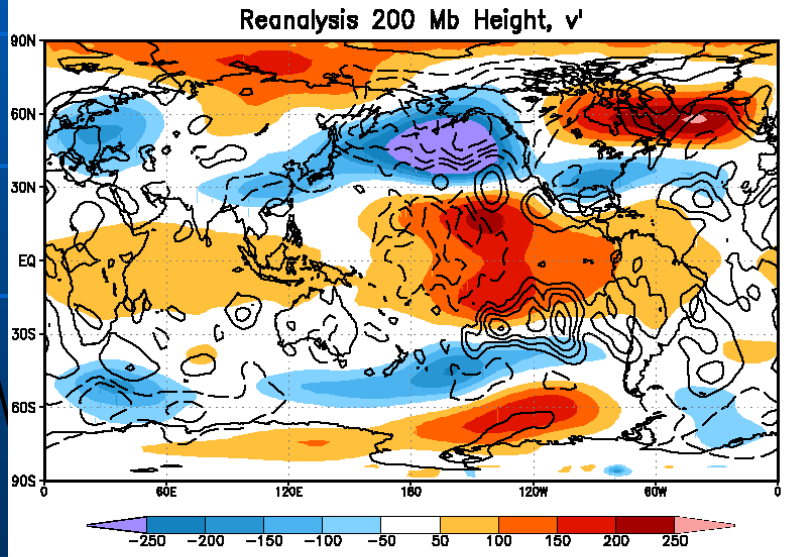


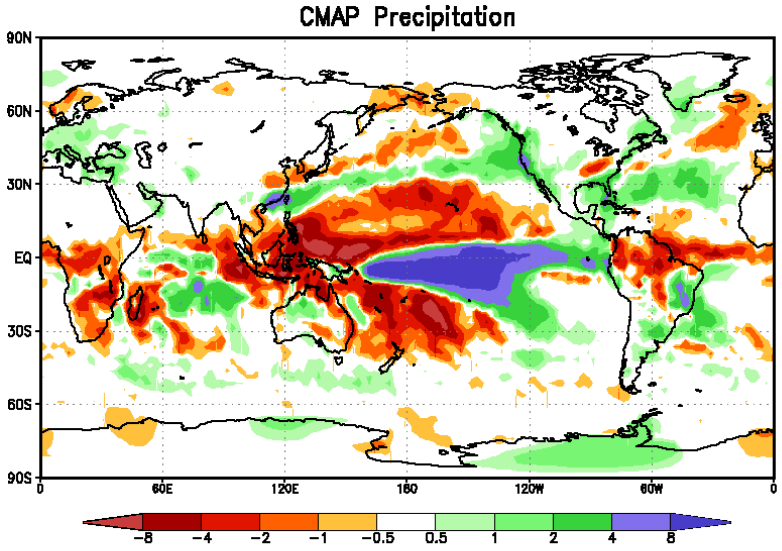
1983 (warm) -1989 (cold) Seasonal Differences

Observations Model (36 members)







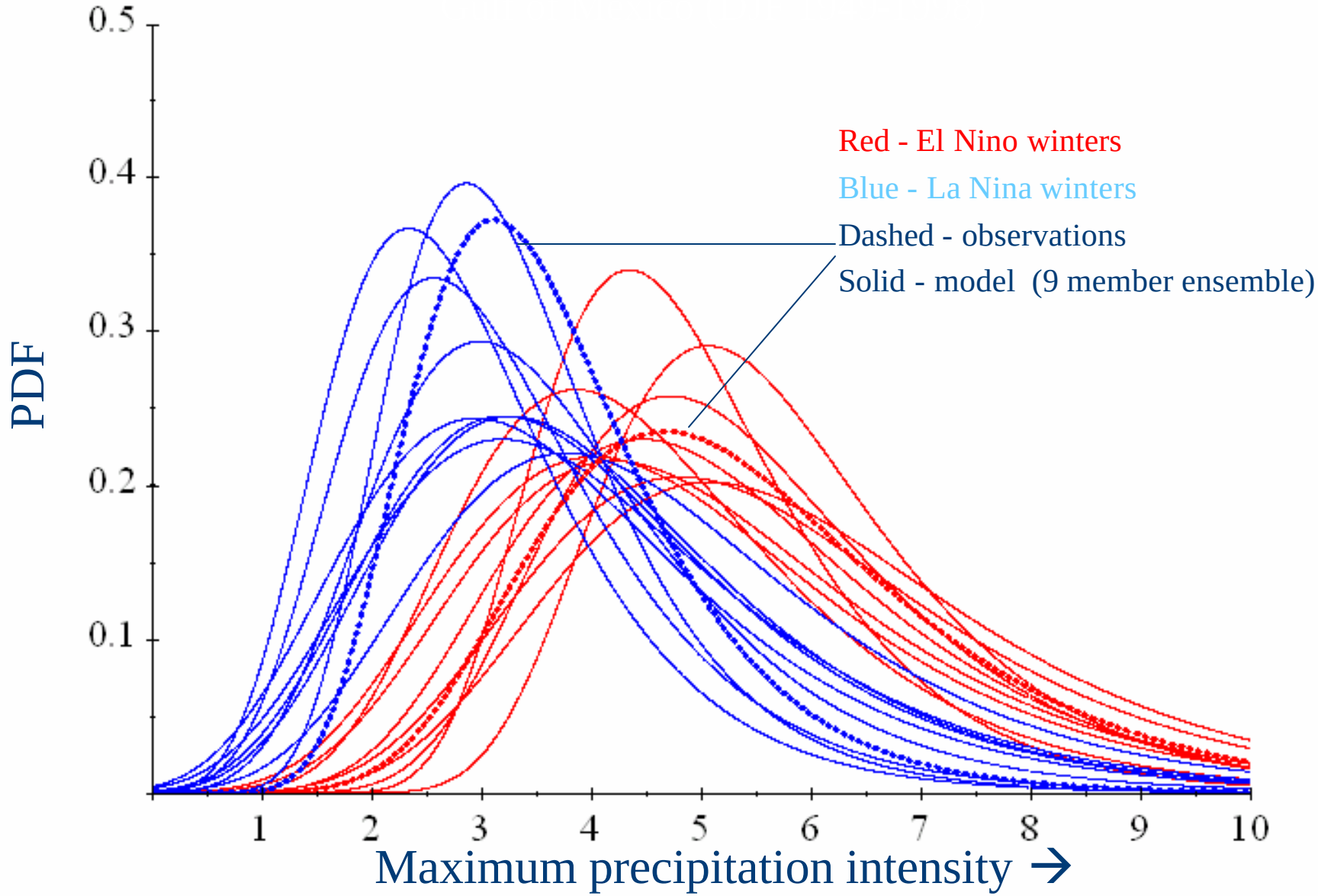


Seasonal (JFM) differences between el Nino (1983) and la Nina (1989) →contours of 200 hPa height, velocity variance and precipitation.

(Schubert et al 2003, GMAO)

Seasonal Prediction:
A Stochastic Problem

- Imbedded weather variability
  - Saturated variability but modulated by ENSO
- Imbedded subseasonal variability
  - Large impact on seasonal uncertainties
- Uncertainties in initial conditions
  - Ocean, land, atmosphere
- Requires an ensemble approach
  - Include uncertainties in forcing and model formulation
  - Difficult to quantify, multi-model approach



Maximum value of the principal components associated with EOF 3 (observations) and EOF 6 (model). Model and observed EOFs are scaled to have the same total variance. The PDFs are the fits to a Gumbel Distribution. (Schubert et al. 2003, GMAO)

Sub-seasonal Prediction:
No single overriding issue

- Models must do many things right
  - Improved tropical/extratropical interactions, MJO
  - Soil moisture feedbacks
  - Extratropical atmos. variability (PNA, NAO, annular modes)
  - Interactions with weather, blocking, stratosphere
- Improved initial conditions in tropics
  - Improved hydrological cycle, precipitation, clouds
- Soil moisture/snow observations to initialize land
- Impact/role of SST not well quantified
- Requires large AGCM ensembles at high resolution
  - Short term: simplified (e.g. mixed-layer) ocean
  - Long term goal is to run fully coupled system (evolve PDF)

Sub-seasonal Prediction:
A bridge between weather and seasonal problem

- Impacts weather predictions
  - Subseasonal “modes” affect low frequency variations in weather predictability
- Impacts seasonal predictions
  - Accounts for much of the unpredictable “noise” at seasonal time scales
- Goal is to evolve PDF from weather to seasonal and longer time scales
  - naturally filters out unpredictable signal at each time scale
  - Requires large coupled model ensembles at high resolution

Short-Term Climate Prediction:
Requirements for Space Observations

- Modeling, Data Assimilation and Science Support
  - Earth System Modeling Framework (ESMF)
  - Support for in-house research and development (Global Modeling and Assimilation Office -GMAO)
  - Support for community research and development (AOs)

- Observations
  - SSH (Topex/Poseidon, Jason-1)
  - SST (MODIS, AMSR)
  - Soil moisture (SMMR, AMSR)
  - Snow (MODIS)
  - Surface and upper atmospheric winds (Quikscat, SeaWinds, windsat, MODIS, MISR, GIFTS)
  - Clouds and precipitation (TRMM, AMSR, MODIS, Cloudsat, GPM)
  - Temperature/humidity profiles (AIRS, AMSU, HSB, GPS, GIFTS)